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Protection, Lobbying, and Market Structure*

Arye Hillman†, *Ngo Van Long*‡, *Antoine Soubeyrand*§

Résumé / Abstract

On analyse un modèle de lobbying par des entrepreneurs qui allouent leur temps entre les activités de supervision. On donne des réponses aux questions suivantes : (i) quelles sont les allocations de ressources en équilibre? Le lobbying pourrait-il renverser l'ordre de rentabilité parmi les firmes? (iii) y a-t-il une corrélation entre le degré de concentration d'une industrie et la protection qu'elle obtient du gouvernement?

We analyze a model of lobbying by oligopolists who allocate resources between lobbying and internal cost-reducing activities. We ask the following questions: (i) if firms differ with respect to comparative advantage in lobbying, what is the equilibrium allocation of resources between lobbying and cost-reducing activities? (ii) can the possibility of lobbying reverse the profitability ranking among firms? (iii) under what condition is the conventional wisdom (that highly concentrated industries tend to obtain more protection) valid?

Mots Clés : Lobbying, oligopole, protection, quota

Keywords: Lobbying, oligopoly, protection, quota

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1 Introduction

There is a presumption, dating at least to Mancur Olson's (1965) classic analysis of collective action, that small group size is advantageous in influencing endogenous policy. The argument is that, under institutions of representative democracy, governments and candidates for political office have political-support needs than can be better satisfied by "cohesive" coalitions, as these are less prone to defection and free-riding than more "diffuse" coalitions . Hence, under representative democracy, "the small exploits the large". In contrast, under direct democracy where voters determine outcomes, larger group size is more advantageous[1]. An implication of the advantage of small group size for collective action is that more concentrated industries should (all else equal) be more successful in securing protection and or in resisting trade liberalization. Empirical studies have however failed to find an unambiguous relation between industry concentration and policy effectiveness of an industry (see sthe surveys by Baldwin 1984, Hillman 1989, Potters and Sloof 1996, and also Goldberg and Maggi 1999). Potters and Sloof (1996, pp.417-418) summarize the diversity of the extensive empirical evidence as follows:

"Most scholars indeed find an increased scope for political influence with higher degrees of concentration, but there are many that find no effect or even a negative effect. Equally ambiguous are the results of the use of numbers for the free rider effect. A large number of participants to collective action is usually hypothesized to increase the free riding problem. Sometimes indeed a negative effect of numbers on influence is reported. More often, however, a positive effect is found. Hence there appears to be relatively little direct empirical support for the Olson (1965) influential theoretical study on collective action."

One may therefore well wonder what is going on. In this paper we consider theoretical foundations for the source of the empirical ambiguities. There are different possible points of departure. One beginning is George Stigler's (1964) proposal that a theory of oligopoly should start by assuming collectively rational behavior, and then should proceed to investigate the costs of defection from the cooperative equilibrium. Stigler's perspective on oligopoly provides a reasonable basis for Olson's collective-action proposition. Smaller group size increases the probability of detection of free-riding behavior and

[1] For an overview of theories of collective action, see Sandler (1992).

decreases the general transactions costs of organizing and monitoring contributions to collective action, and so, according to Stigler, more concentrated industries are expected to be more effective in influencing endogenous policy decisions. This is not however the unambivalent picture provided by the empirical evidence. The alternative non-cooperative Cournot-Nash approach adopts as a point of departure individually rational behavior. Policy influence then becomes a case of non-cooperative private provision of a public good.

In the latter approach, we have well-established results for the case where consumers choose public good provision (see Cornes and Sandler 1996). If the public good is a normal good, there are countervailing substitution and income effects on the contribution decisions of other consumers when one consumer increases his or her Nash contribution, so that a larger contribution by one consumer need not decrease the contribution of other consumers. Increasing group size and thereby adding a new prospective contributor to the public good therefore can either increase or decrease total contributions. Also, the total Nash-equilibrium contribution by consumers to provision of a public good is independent of the distribution of income among those consumers who are making positive contributions to provision of the good (Warr 1983, Kemp 1984, Bergstrom, Bloom and Varian 1986).

The analogy to firms in an industry making contributions in pursuit of a collective policy objective is investigated in Hillman (1991). Consumers are replaced by owners of firms who allocate time and attention between the privately beneficial activity of monitoring their firms' production activities[2] and the public-good benefit of persuading policy makers to implement policies that benefit the entire industry. Firm owners have different comparative advantages in lobbying for protection[3]. Results are obtained that are analogous to the consumer outcome: redistribution of aggregate industry profits among a given number of firms in the industry, as implied by a change in the size distribution of firms or industry concentration, need not change the aggregate Nash contribution of resources by firms in the industry to the collective benefit of influencing policy. Prospective neutralities are therefore introduced into the relation between industry concentration and the effec-

[2]For an elegant treatment of the monitoring role of managers, see Vousden and Campbell (1994).

[3]Or, rather than firm ownership, management incentive schemes can provide the same incentive to lobby for industry protection even when this is not in the best interests of diversified owners of firm. See Cassing (1996).

tiveness of the collective pursuit of policies beneficial to the industry; that is, changes in concentration as measured by the distribution of profits among a given number of firms can leave unaffected the political influence of the industry as measured by the total resources allocated by the industry to policy persuasion. Changing group size by increasing the number of firms, the neutralities appear when managerial time and attention available for allocation between productive activity and seeking political influence is an industry-specific input, but not when such inputs are intersectorally mobile.

The model in Hillman (1991) assumes that the domestic industry wherein firms are contributing to collective policy objective confronts a competitive world market. International prices of import-competing output are thus exogenously determined, and the domestic price is determined by the given world price plus the protection provided as a consequence of firms' contributions to lobbying efforts. The strategic interdependence amongst firms is thus only with respect to contributions to influencing policy, and not with respect to competition in the product market. This permits the industry seeking protection (or resisting liberalization) to be placed within the broader context of a competitive small-country model of international trade.

In this paper we consider the relation between industry concentration and policy effectiveness in an internationally oligopolistic industry rather than an internationally competitive industry. As in Hillman (1991), the firms seeking protection are heterogeneous (see also Long and Soubeyran 1996), and trade policy is endogenously responsive to the total resources contributed by domestic firms to influencing policy. In our model, we show that the amount of resources that an oligopolist deploys for lobbying has an impact on the internal cost structure of the oligopoly, under the assumption that either each firm faces a resource constraint, or each firm faces an upward-sloping curve of the marginal cost of funds that are to be allocated between political activities and internal cost-reducing activities. Because of these factors, as well as the oligopolistic market structure and the consequent endogeneity of domestic price, contributions by firms to influencing policy no longer have the characteristics of contributions to a pure public good. We show how in these circumstances the industry equilibrium is influenced by the properties of the lobbying technology and the domestic demand function, and we establish how an index of concentration is related to effectiveness of collective action of the industry. The specific questions which we address are: (i) With firms differing in comparative advantage in lobbying, what are the characteristics of the equilibrium allocations by firms between privately profitable monitoring and collectively beneficial lobbying activities? (ii) Can the ranking of firms' profitability be reversed by the introduction of lobbying possibilities? And most basically: (iii) What can be said about the conventional wisdom that more concentrated industries should obtain more protection?

The model which provides the framework for these questions is set out in Section 2. We consider the outcomes when lobbying by firms is non-cooperative and cooperative in Sections 3 and 4 respectively. The final section summarizes the conclusions.

Before proceeding with the model, we note that our endogenous-policy specification is general in not presupposing any one particular mechanism which translates lobbying inputs into endogenous policy outcomes[4]. We simply assume that an increase in the resources available to the industry to influence policy enhances the lobbying effectiveness of the industry. The model is in principle consistent with an underlying political-support function of an incumbent government (for example Hillman 1982) or influence over candidates' trade policy platforms in the context of political competition (Hillman and Ursprung 1988, Mayer 1998). In neither type of specification in the literature do we find an investigation of the collective-action incentives associated with industry concentration with which we are concerned[5]. For example, in the micro-foundations for political support proposed by Grossman and Helpman (1994), either an industry has been successful in perfectly internalizing collective action problems to permit collectively optimal political behavior, or otherwise the industry is not at all politically active[6]. Hence, in Grossman-Helpman, the issue of the market structure of the industry, and the consequences for collective action in responding to the policy maker's readiness to "sell protection", do not at all arise. In models where trade policy is endogenously determined as the equilibrium outcome of political competition (as in Hillman-Ursprung 1988), market structure implicitly affects the competing candidates' policy platforms, but in a rather simple way because of the homogeneity of firms; the political competition models can in principle address the issue of the relation between concentration and

[4]See Potters, Sloof, and van Winden (1997) for a model which encompasses different channels of influence on voters decisions.

[5]The issue is also not addressed in the surveys by Magee (1984) and Rodrik (1995).

[6]Grossman and Helpman indeed require the assumption that some industries are not politically active to avoid a free-trade policy equilibrium, since their choice of equilibrium implies a Pareto-efficient outcome if all industries are politically active. See also Mitra (1995).

effectiveness of policy influence, but only in the sense of measurement of industry concentration in terms of the number of identical firms composing the industry[7].

2 The Model

There are n firms producing a homogenous good. The first k firms are domestic firms and the remaining $n-k=k^*$ firms are foreign firms. Let $K=\{1,2,...,k\}$ and $K^*=\{k+1,....k+k^*\}$. Their outputs are denoted by q_i, $i\in K$, and q_j^*, $j\in K^*$. Let

$$Q=\sum_{i\in K}q_i \quad , \quad Q^*=\sum_{j\in K^*}q_j \quad , \quad Z=Q+Q^*$$

All the outputs are sold in the home country, where the inverse demand function is $P=P(Z)$, $P'<0$.

The unit variable cost of firm i is c_i. It is independent of the output level, but is dependent on the amount of resources (which may be entrepreneurial time, or funds) devoted to internal cost-reducing activities (such as monitoring or R&D), which we denote by m_i. We assume that $c_i(0)=\bar{c}>0$ and $c_i'(m_i)\leq 0$. Each domestic firm has a total amount h_i of resources to be allocated between cost-reducing activities and lobbying. Let a_i denote the amount of resources devoted to lobbying, then $a_i=h_i-m_i$. Concerning the quantity h_i, we consider two cases: in case (i), the amount h_i is fixed (exogenously given), and in case (ii), the amount h_i can be chosen, but the firm must incur a cost $\Omega(h_i)\geq 0$ to obtain h_i, and Ω', the marginal cost of obtaining h_i, is an increasing function of h_i. A possible interpretation of case (i) is that firms have a certain fixed amount of money (or time) to spend on the two classes of activities mentioned above, and if they spend more on lobbying, then less will be spent on internal activities. A possible interpretation of case (ii) is that h_i represents the amount of money that can be obtained from financial institutions, but the marginal cost of loans, denoted

[7]The political competition models of endogenous trade-policy determination are similar to models of rent seeking for public goods (see the survey of the rent-seeking literature by Nitzan 1994). Although the model structures are similar (see Urpsrung 1990), the rent-seeking models focus on establishing the social loss incurred via resource dissipation in different circumstances, whereas the political-competition models of trade focus on establishing the characteristics endogenous equilibrium policies.

by $\Omega_i'(h_i)$, is increasing. Alternatively, if h_i is the amount of time devoted to monitoring and lobbying, then $\Omega(h_i)$ is the entrepreneur's evaluation of lost leisure. In both case (i) and case (ii), if the resources are money rather than entrepreneurial time, then some sort of capital market imperfection must be in the background. In the finance literature, it has been argued that credit rationing is a response to asymmetric information, and rising marginal cost of loans is a reflection of firm-specific risks, which make the I.O.U. s issued by the firm a specific asset without perfect substitutes.(See, for example, Milne 1975, Hellwig 1989, and Bester and Hellwig 1987.) In what follows, we focus on case (i), because the analysis of that case is relatively simpler. Results for case (ii) are similar to those obtained in case (i), and they are reported in the Appendix.

While a great deal of lobbying activities are undertaken by hired professional lobbyists, the importance of entrepreneurial time in lobbying (and, more generally, in public relation activities) is also well recognized in the business world. The frequent public appearances of well-known individuals such as Lee Ioccoca and Bill Gates are not without opportunity costs in terms of internal controls. In Canada, when chief executive officers are chosen, an important criterion is their connection with Ottawa[8].

We assume that firms lobby in order to convince the government to impose a quota B on the aggregate import of the good. We postulate that B is a decreasing function of aggregate lobbying effort, $A = \sum_{i \in K} a_i$ and that there is diminishing returns to lobbying:

$$B'(A) < 0, \quad B''(A) > 0$$

In what follows, for simplicity, the quota is taken to be binding always, so that $Q^* = B$, and $Z = B + Q$. It does not matter, therefore, if foreign firms are oligopolists or not. Domestic firms solve their optimization problem in two stages. In Stage 1, the a_i's are chosen, either cooperatively or non-cooperatively, and this determines the quota B, and the amount $m_i = h_i - a_i \geq 0$ is spent on internal cost-reducing activities (monitoring, or R&D). In Stage 2, given B, domestic firms choose non-cooperatively their output levels. The game in Stage 2 is a simple Cournot game, the solution of which is described below.

Given m_i, firm i's unit cost is $c_i(m_i)$, which we denote by c_i for short. Firm i takes as given the import volume B and the total output of all other

[8]See, for example, the Globe and Mail (11 March, 1999).

domestic firms, denoted by Q_{-i}. It chooses q_i to maximize profit

$$\pi_i = P(B + Q_{-i} + q_i)q_i - c_i q_i \tag{1}$$

This yields the first order condition for an interior maximum

$$q_i P'(B + Q_{-i} + q_i) + P(B + Q_{-i} + q_i) = c_i \tag{2}$$

The second order condition is

$$s_{id} E_d < 2 \tag{3}$$

where $s_{id} \equiv q_i/Q$ is domestic firm i's market share of domestic output, and $E_d \equiv (QP'')/[-P']$ is the elasticity of the slope of the residual (ie, net of imports) demand curve. Summing the first order condition over all domestic firms yields

$$QP'(B + Q) + kP(B + Q) = C \equiv \sum_{i \in K} c_i \tag{4}$$

Equation (**??**) shows that given the quota B, domestic output Q is a function of the sum of unit costs, C. Let us denote the left-hand side of (**??**) by $\psi(Q, B)$. We assume that $\psi_Q < 0$. This condition may be expressed as

$$E_d < k + 1 \tag{5}$$

Condition (**??**) is one of the usual stability conditions of a Cournot equilibrium, see Dixit (1986). Given this assumption, we can use equation (**??**) to obtain the equilibrium domestic output as a function of B and C, $Q = Q(B, C)$,with

$$\frac{\partial Q}{\partial B} = \frac{k - E_d}{E_d - k - 1} \quad , \quad \frac{\partial Q}{\partial C} = \frac{1}{[-P'][E_d - k - 1]} < 0 \tag{6}$$

It follows that total demand, $Z = B + Q$, is a function of B and C, $Z = Z(B, C)$,with

$$\frac{\partial Z}{\partial B} = \frac{-1}{E_d - k - 1} > 0, \quad \frac{\partial Z}{\partial C} = \frac{1}{[-P'][E_d - k - 1]} < 0 \tag{7}$$

Equation (**??**) shows that lobbying has two effects on equilibrium supply and hence price. An increase in lobbying will reduce the quota B, thus raising the equilibrium domestic price. In addition, an increase in lobbying means that, for a *given* h_i, less resources will be available for monitoring (or R&D), hence cost will rise, and this reduces equilibrium domestic output, causing a further upward pressure on price. (In case (ii), which we analyse briefly in the Appendix, h_i can be increased, but then a higher marginal cost of funds, $\Omega'(h_i)$, will be incurred; thus in this case an increase in lobbying will also has an impact on the cost of internal activities.) Note that while B depends only on the *sum* of the a_i's, the variable C depends on the whole vector $a = (a_1, ..., a_k)$ and *not on the sum* of the a_i's. This observation is crucial, because it means that the model of Bergstrom, Blume and Varian (1986), which postulates that only the sum of the contributions matters, *does not apply* to our more complex situation.

Let us turn to the equilibrium output of firm i. From (**??**) we have

$$q_i = \frac{P[B + Q(B, C)] - c_i}{\{-P'[B + Q(B, C)]\}} \tag{8}$$

and its equilibrium profit is

$$\pi_i = \{P - c_i\}q_i = \frac{\{P[B + Q(B, C)] - c_i\}^2}{\{-P'[B + Q(B, C)]\}} \tag{9}$$

In what follows, we assume that if c_i falls while all the c_j's ($j \neq i$) remain constant, then the equilibrium profit will rise. It can be shown that this assumption is satisfied if

$$(2 - s_{id})E_d \leq 2k \tag{10}$$

(i.e., if the demand curve is not too convex.)

We now turn to the analysis of the equilibrium in stage 1, the lobbying stage.

3 Non-cooperative Lobbying

In this section we assume that firms undertake lobbying activities in a non-cooperative way. This is an instance of a class of problems known as "the private provision of a public good." A *special case* of this class of problems has been analyzed thoroughly by Bergstrom, Blume, and Varian (1986), where they assume that (i) in the production of the public good, only the sum of the contributions, $A \equiv \sum a_i$, matters, and that (ii) the payoff to each player depends only on this sum, A, and on his own contribution, independently of how much each of the other players contributes. As we have stated above, their restrictive assumptions mean that their model is not applicable to our problem, where each firm i's payoff depends not only on A but also on C, and the latter is not a function of the sum A. Clearly, it is important how C depends on the individual contributions a_i's. In what follows, we will focus on three alternative specifications of the relationship between C and the a_i's. Let us write

$$c_i(m_i) = \bar{c} - r_i(m_i)$$

where $r_i(m_i)$ may be interpreted as the reduction in unit cost due to monitoring.

Specification 1: increasing returns to monitoring.

$$r_i(m_i) = \delta_i m_i^{\alpha} \quad , \quad \alpha > 1, \quad \delta_i > 0, \quad 0 \leq m_i \leq h_i$$

Specification 2: decreasing returns to monitoring.

$$r_i(m_i) = \delta_i m_i^{\epsilon} \quad , 0 < \epsilon < 1, \quad \delta_i > 0, \quad 0 \leq m_i \leq h_i$$

Specification 3: constant returns to monitoring.

$$r_i(m_i) = \delta_i m_i \quad , \quad \delta_i > 0, \quad 0 \leq m_i \leq h_i$$

Since $m_i = h_i - a_i$, it is convenient to define

$$\theta_i(a_i) = \bar{c} - r_i(h_i - a_i) \tag{11}$$

and $\theta_i'(a_i)$ may be interpreted as the marginal cost of lobbying, because it measures the increase in production cost when entrepreneurial resources are diverted away from internal cost-reducing activities. Let $a = (a_1, ..., a_k)$.Then, with a slight abuse of notation, $Z(B, C) = Z(a)$. From (**??**), firm i's profit in stage 2 is

$$\pi_i = \frac{[P(Z(a)) - \theta_i(a_i)]^2}{[-P'(Z(a))]} \tag{12}$$

To find firm i's optimal choice of a_i , given the a_j's ($j \neq i$), we maximize (**??**) subject to the constraints $h_i - a_i \geq 0$ and $a_i \geq 0$. Write the Lagrangian

$$L = \pi_i + \lambda_i[h_i - a_i] + \mu_i a_i$$

The first order condition is

$$\frac{\partial L}{\partial a_i} = M(a_i)N(a_i) - \lambda_i + \mu_i = 0$$

where

$$M(a_i) \equiv \frac{P - \theta_i(a_i)}{[-P'](k + 1 - E_d)} > 0$$

and

$$N(a_i) \equiv -[2k - E_d(2 - s_{id})]\theta_i' + [2 - s_{id}E_d]B'P'$$

At an interior maximum, we must have

$$\theta_i'(a_i) = \frac{[2 - s_{id}E_d]B'P'}{[2k - E_d(2 - s_{id})]} \tag{13}$$

(note that both $2 - s_{id}E_d$ and $2k - E_d(2 - s_{id})$ are positive, by (**??**) and (**??**).) Condition (**??**) has an intuitive interpretation: at an interior maximum, an increase in the amount of resources devoted to lobbying will increase production cost by θ_i', (this is the marginal cost of lobbying) and this must be balanced by the marginal gain from lobbying, which consists of an increase in price (modified for factors such as market share, and the effect of a price rise on revenue) brought about by a decrease in the import quota. The maximum may occur at a corner: zero contribution to lobbying, if $\theta_i'(0)$ exceeds the marginal gain (the right-hand side of (**??**)); or maximum contribution, $a_i = h_i$, if $\theta_i'(h_i)$ is smaller than the marginal gain.

The second order condition for an interior maximum is $M'(a_i)N(a_i) + M(a_i)N'(a_i) < 0$, which amounts to $N'(a_i) < 0$ because $N(a_i) = 0$ at an interior maximum. If the demand function is linear, $P = a - bZ$, the second order condition simplifies to

$$-k\theta_i''(a_i) - bB''(A) < 0 \tag{14}$$

which is satisfied if θ'' is positive, or not too negative.

The first order condition (**??**) can also be written as

$$s_iE = 2 - 2\gamma_i[k + 1 - sE] \tag{15}$$

where $s_i \equiv q_i/Z$, $s \equiv Q/Z$, $E \equiv [ZP'']/[-P']$, and γ_i is defined by

$$\gamma_i \equiv \frac{\theta_i'(\hat{a}_i)}{\theta_i'(\hat{a}_i) + P'B'(\hat{A})} \tag{16}$$

where all the derivatives are evaluated at the Nash equilibrium, and the hat over a variable indicates its equilibrium value. Equation (**??**) relates firm i's equilibrium market share to γ_i, which may be taken as a measure of its comparative advantage in internal cost-reducing activities (which from now on we will refer to as monitoring for brevity.)

We now seek to determine how the heterogeneity among firms with respect to lobbying skills affect their relative contributions. Here several concepts of comparative and absolute advantage present themselves. We list below a few indicators.

(i) An indicator of **absolute advantage** in monitoring: If $\delta_i > \delta_j$ then firm i is said to have absolute advantage in monitoring over firm j.

(ii) An indicator of **comparative advantage** in monitoring: Firm i is said to have comparative advantage in monitoring over firm j if and only if $\gamma_i > \gamma_j$, where γ_i is defined by (**??**). This definition is motivated by the idea that a firm that has comparative advantage in monitoring would have a high θ_i' , i.e., a high marginal cost of undertaking lobbying activities, see Remark 1 below.

(iii) An equivalent ranking can be obtained by the following definition

$$\beta_i = \frac{1}{\gamma_i} - 1 = \frac{P'B'(\hat{A})}{\theta_i'(\hat{a}_i)} \tag{17}$$

If $\beta_j > \beta_i$ then firm j is said to have **comparative advantage in lobbying**. Note that $\beta_j > \beta_i$ if and only if $\gamma_j < \gamma_i$.

The following remarks are in order. From (**??**) the indicator γ_i is defined using equilibrium values. It should be noted that

$$sgn[\gamma_i - \gamma_j] = sgn[\theta_i'(\hat{a}_i) - \theta_j'(\hat{a}_j)] \tag{18}$$

where sgn means 'the sign of'.Under Specification 3 (constant returns to monitoring), $\gamma_i > \gamma_j$ if and only if $\delta_i > \delta_j$. Thus, under constant returns to monitoring, comparative advantage *amounts to the same thing* as absolute advantage.

We now present some results for the case of linear demand, $P = P^0 - bZ$, where $P^0 > 0$, and $b > 0$.

Proposition 3.1: Assume linear demand and increasing returns in monitoring (i.e., specification 1). Then

(a) at an interior Nash equilibrium of the lobbying game, firms that are less efficient in monitoring in absolute terms (low δ_j) will devote more entrepreneurial resources to monitoring, and achieve lower cost and greater profit than other firms. Thus, the availability of lobbying opportunities **reverses the ranking of firms' profitability** if the Nash equilibrium is interior.

(b) there may exist a corner solution which also has the property of profitability ranking reversal.

Proof:

(a) From (**??**), with $E_d = 0$ because of linear demand, we have at an interior equilibrium

$$\theta_i'(a_i) = \alpha \delta_i m_i^{\alpha-1} = \frac{P'B'}{k} = \theta_j'(a_j)$$

It follows that if $\delta_i > \delta_j > 0$ then, since $\alpha > 1$,

$$\frac{m_j}{m_i} = \left[\frac{\delta_i}{\delta_j}\right]^{1/(\alpha-1)} > 1$$

Therefore, at the interior Nash equilibrium,

$$c_j(m_j) = \bar{c} - \left[\frac{P'B'}{\alpha k}\right] m_j < c_i(m_i)$$

This shows that if two firms (i, j) have $\delta_i > \delta_j > 0$ and $h_i = h_j$, then, in the absence of lobbying opportunities, firm i would have lower cost and thus higher profit than firm j, but, when lobbying opportunities become available, at an interior Nash equilibrium, firm i will have higher cost and thus lower profit than firm j.

(b) To prove part (b), it suffices to provide a numerical example. Assume there are only two domestic firms. Let $P^0 = 100$, $\bar{c} = 20$, $b = 1$, $\alpha = 2$, $\delta_1 = 2$, $\delta_2 = 1$, $h_1 = h_2 = 5$. Assume that the function $B(A)$ takes the simple form: $B(A) = 10(5 - A)^2$ if $0 \leq A \leq 5$ and $B(A) = 0$ if $A \geq 5$. Then the reaction functions of the lobbying game has the following properties. (See Figure 1.)

The reaction function of firm 1, $a_1 = R_1(a_2)$ is given by: $R_1(a_2) = 5$ if $a_2 = 0$, $R_1(a_2) = 5 - 5a_2$ if $0 \leq a_2 \leq 1$, and $R_1(a_2) = 0$ if $a_2 > 1$.

The reaction function of firm 2, $a_2 = R_2(a_1)$ is given by: $R_2(a_1) = 5$ if $a_1 = 0$, $R_2(a_1) = 5 - (5/3)a_1$ if $1 \leq a_1 \leq 3$, and $R_2(a_1) = 0$ if $a_1 > 3$..

There are three Nash equilibria. The first Nash equilibrium is an interior one, with equilibrium values (a_1, a_2)=(30/11, 5/11). The second Nash equilibrium is (a_1, a_2)=(5, 0), and the third Nash equilibrium is (a_1, a_2)=(0, 5). At the first two equilibria, firm 1 earns less profit than firm 2, which shows that their profit ranking is reversed. Note that the interior equilibrium in this two-firm example is unstable, while the remaining two equilibria are stable.□

The intuition behind Proposition 3.1 is as follows. If lobbying opportunities do not exist, then, other things being equal, firms with a higher δ will have lower costs and therefore higher outputs and profits. When firms can lobby, these large firms will tend to divert a lot of entrepreneurial resources to lobbying activities, because they expect a large gain from the rise in price that accompanies tighter import quotas. Suppose there are just two domestic firms, and firm 1 is more efficient in monitoring ($\delta_1 > \delta_2$). Then firm 1's marginal-cost-of-lobbying schedule, $\theta_1'(a_1)$ is everywhere above that of firm 2 if h_1 is equal to or is not too different from h_2 (See Figure 2, where $\theta_1'(x) > \theta_2'(x)$ for any common x.) These schedules are downward-sloping because α is greater than 1. Firm 1, anticipating that the equilibrium $\hat{a}_2$ is small (the hat denotes the equilibrium value), perceives correctly that its marginal-benefit-of-lobbying schedule is quite high. Therefore it sets a high $\hat{a}_1$. Firm 2, knowing that $\hat{a}_1$ is high, perceives its marginal-benefit-of-lobbying schedule to be quite low, so its low $\hat{a}_2$ is justified. The outcome is almost a free-ride for firm 2. (In the example given in part (b) of the proof, this free ride for firm 2 occurs at the first two Nash equilibria, but not at the third Nash equilibrium.)

For the case of decreasing returns in monitoring, the profitability ranking is not reversed when lobbying opportunities are available:

Proposition 3.2: Assume linear demand and decreasing returns in monitoring (ie, specification 2). Then, at an interior Nash equilibrium, firms that are less efficient in monitoring in absolute terms (low δ_j) will devote less entrepreneurial time to monitoring, and achieve higher cost and lower profit than other firms.

Figure 3 illustrates Proposition 3.2.

Another interesting question is whether an increase in the number of firms will reduce the aggregate lobbying effort. The answer is given by Proposition

3.3.

Proposition 3.3: Assume that the demand function is linear, $P = a - bZ$, and that all domestic firms are identical. Then an increase in the number of firms, without changing the endowment h_i of each firm, will reduce aggregate lobbying effort if and only if $a\theta''(a)/\theta'(a) < 1$ (ie, iff the elasticity of θ' is less than 1).

Proof:

With linear demand and identical firms, the first order condition (**??**) becomes

$$-k\theta'(A/k) - bB'(A) = 0$$

This equation yields

$$\frac{dA}{dk} = \frac{\theta' - \theta'' A/k}{[-\theta'' - bB'']}$$

where the denominator is negative because of (**??**) and $k \geq 1$, and the numerator is positive if $a\theta''(a)/\theta'(a) < 1$.□

We now turn to the non-linear demand case. In this case it is convenient to make use of condition (**??**). The following proposition relates the comparative advantage in monitoring with equilibrium market shares and profits.

Proposition 3.4: Assume non-linear demand. Then at an interior Nash equilibrium,

(a) If the demand curve is locally concave ($E < 0$), then firms that have greater *comparative advantage* in monitoring will have greater market shares and greater profits.

(b) If the demand curve is locally convex ($E > 0$), then firms that have greater *comparative advantage* in monitoring will have smaller market shares and smaller profits. (In other words, the availability of lobbying opprtunities *reverses* the profit ranking.)

Proof:

From (**??**), with $E \neq 0$,

$$s_i - s_j = \frac{2(\gamma_j - \gamma_i)[k + 1 - sE]}{E} \tag{19}$$

It follows that

$$sgn[s_i - s_j] = sgn[-E] sgn[\gamma_i - \gamma_j] \tag{20}$$

that is, $s_i - s_j$ has the same sign as that of $\gamma_i - \gamma_j$ if $E < 0$, and has opposite sign as that of $\gamma_i - \gamma_j$ if $E > 0$. Finally, from (**??**) $\pi_i = [-P']q_i^2 = [-P']Z^2 s_i^2$. $\square$

In order to understand the intuition behind Proposition 3.4, we must explicate the role of E. The following lemma is useful for that purpose. (A similar result for the tariff case was independently proved by Collie, 1993, and Long and Soubeyran, 1997.)

Lemma 3.1. If $E < 0$ [respectively, $E > 0$] so that the demand curve is concave [respectively, convex], then an exogenous reduction of import quota will expand the equilibrium output of lower cost domestic firms by more [respectively, by less] than that of higher cost domestic firms.

Proof:

Assume without loss of generality that firm i has lower cost than firm j ($c_j - c_i > 0$). From (**??**) and (**??**),

$$q_i - q_j = \frac{1}{[-P']}(c_j - c_i)$$

and hence

$$\frac{d}{d(-B)}[q_i - q_j] = \frac{1}{[-P']^2}\,(c_j - c_i)\,P''\left[\frac{\partial Z}{\partial(-B)}\right]$$

which is positive if $E < 0$.$\square$

It follows from Lemma 3.1 that if $E < 0$ then lower cost firms have a stronger incentive to contribute to lobbying. They devote more resources to lobbying, while still maintaining lower production costs. Figure 4 illustrates the equilibrium when firm 1 has a comparative advantage in monitoring and $E < 0$. Its marginal cost of lobbying, θ_1' is therefore higher. If it expects a_2 to be small in equilibrium, then its marginal benefit curve (as a function of a_1) is also high (recall that E is negative) and in equilibrium, its contribution to lobbying could be slightly more than that of firm 2, without harming its cost ranking.

In the opposite case where $E > 0$, all domestic firms still gain from lobbying, but the higher cost firms expand more relative to the lower cost firms. One may ask why the lower cost firms do not pretend to be higher cost firms, by contributing less to lobbying, in order to gain more. The answer lies in the fact that they know if they were to do so, there would be less aggregate lobbying, which would be bad for everyone in the home industry.

We now consider a very special case where all $\delta_i = \delta_j$ for all i, j, so that firms differ only with respect to endowments : $h_i \neq h_j$. In this case we obtain the following:

Proposition 3.5: If $\delta_i = \delta_j$ for a pair i, j, so that these two firms differ only with respect to endowments, then at a Nash equilibrium where both i and j contribute, they must achieve the same market share and hence the same comparative advantage in monitoring if (i) $E < 0$ and $r(m)$ is strictly concave, or (ii) $E > 0$ and $r(m)$ is strictly convex.

Proof:

Take the case $E < 0$ and $r(m)$ strictly concave. Then from (**??**) and (**??**), if both firms contribute, then $sgn[s_i - s_j] = sgn[\theta_i'(\hat{a}_i) - \theta_j'(\hat{a}_j)]$.

Suppose $s_i \neq s_j$. Say $s_i > s_j$. Then $\theta_i'(\hat{a}_i) > \theta_j'(\hat{a}_j)$, which is true if and only if $\delta r'(h_i - \hat{a}_i) > \delta r'(h_j - \hat{a}_j)$, if and only if $\hat{m}_i < \hat{m}_j$. This would imply $c_i > c_j$ and hence $s_i < s_j$, a contradiction. It follows that $s_i = s_j$ if both firms contribute.$\square$

From Proposition 3.5 if two firms are identical except for a slight difference in endowments then at an interior equilibrium their contributions differ by exactly their difference in endowments. If their endowments greatly differ from each other, it is likely that only one firm contributes while the other free rides.

4 The Cooperative Case

We now consider the case where firms coordinate their lobbying activities, even though they are Cournot rivals in the product market. This specification is quite realistic, and is consistent with the theory of semi-collusion (as exemplified by the by the works of Friedman and Thisse 1993, Fershtman and Gandal 1994, Nalebuff and Brandenburger 1996, Long and Soubeyran 2000, among others), which is based on the observation that firms often cooperate in some sphere while compete in other spheres.

The cooperative case is more complicated because in the first stage of the game there are incentive for firms to change the cost structure within the industry so as to reduce rivalry in the second stage. In other words, allocation of lobbying efforts now serves two distinct purposes. The first purpose is to increase protection against foreign imports, and the second purpose is to alter the composition or degree of concentration of the domestic industry. Coordination of lobbying may thus be seen as a surrogate for cooperation in the second stage (which is often prohibited by anti-trust laws). In fact, as we will see below, even if firms are ex-ante identical in technology and endowment, their optimal coordination of lobbying effort may call for asymmetric contributions.

In order to handle these complicated issues, we must find a relationship between aggregate profit of the domestic firms and their cost structure.

Recall that firm i's unit cost is

$$\theta_i(a_i) = \bar{c} - r_i(h_i - a_i)$$

It is convenient to define the inverse function

$$a_i = a_i(r_i)$$

where r_i is now real number representing the reduction in unit cost below the maximum level $\bar{c}$. Let r_K denote the mean reduction in unit cost:

$$r_K \equiv \frac{1}{k} \sum_{i \in K} r_i$$

The sum of the unit costs is:

$$C = k(\bar{c} - r_K)$$

Recall that the equilibrium quantity is $Z = B + Q(B, C)$, where $B = B(A)$.This can now be written as

$$Z = Z(A, k(\bar{c} - r_K))$$

The sum of the equilibrium profits of the domestic firms is

$$\Pi = \sum_{i \in K} \pi_i = \frac{k\{P - \bar{c} + r_K\}^2}{[-P']} + \frac{1}{[-P']} \sum_{i \in K} (r_i - r_K)^2 \tag{21}$$

(for a proof, see Long and Soubeyran 1996). This formula indicates that for a given A and a given r_K (so that both P and P' are fixed), industry profit can be increased by increasing the variance V of the cost reduction, where

$$V \equiv \frac{1}{k} \sum_{i \in K} (r_i - r_K)^2$$

To illustrate this possibility, consider the case where $r_i(m_i) = \delta_i m_i^\alpha = \delta_i(h_i - a_i)^\alpha$, with $\alpha > 1$ Then the function $a_i(r_i)$ is convex:

$$a_i(r_i) = h_i - \left[\frac{r_i}{\delta_i}\right]^{1/\alpha}$$

Summing over all i, we obtain

$$\sum_{i \in K} \left[\frac{r_i}{\delta_i}\right]^{1/\alpha} = \sum_{i \in K} h_i - A$$

For a *given* A and a *given* r_K, the set of feasible $(r_1, ..., r_k)$ is illustrated in Figure 5 for the case $k = 2$. The reader can also visualize the feasible set for the case $k = 3$, where clearly the optimal solution to the problem of maximizing Π in (**??**) subject to a given A and a given r_K is asymmetric. This result on asymmetric contributions is stated as Proposition 4.1:

Proposition 4.1 (Asymmetric contributions)
In the cooperative lobbying case, firms may have incentive to agree on asymmetric contributions even when they are ex-ante identical.

In the case of constant returns to monitoring, an asymmetric solution will also typically arise. It suffices to illustrate this result for the case of two firms and linear demand, $P(Z) = \bar{P} - Z$. We now show that for any given aggregate amount $A < \max\{h_1, h_2\}$ devoted to lobbying, given Cournot competition in stage 2, industry profit is maximized in stage 1 by having all the lobbying done by only one firm. The proof is as follows. Given A, the equilibrium price under Cournot rivalry is $\widehat{P} = (1/3)[\bar{P} - B(A) - \theta_1(a_1) - \theta_2(a_2)]$, where $\theta_1(a_1) = \bar{c} - \delta_1(h_1 - a_1)$ and $\theta_2(a_2) = \bar{c} - \delta_2(h_2 - a_2)$ where $a_2 = A - a_1 \geq 0$. Total profit, for a given A, is $\left[\widehat{P} - \theta_1\right]^2 + \left[\widehat{P} - \theta_2\right]^2 \equiv \Pi(a_1)$. This expression is strictly convex in a_1. Maximizing $\Pi(a_1)$ with respect to a_1 subject to $a_1 \geq 0$ and $A - a_1 \geq 0$ results in a corner maximum.

In an asymmetric contribution cooperative equilibrium, some firms may be asked not to contribute to lobbying activities. These firms will earn more profits than others, in the case of ex-ante identical firms. We do not specify in this paper how the aggregate industry profit is to be distributed among firms. A possible approach is to assume that firms make side transfers to each others, so that no firm will envy other firms. Such an approach has been formalized in Long and Soubeyran (1999) in the context of formation of a research joint-venture by rival oligopolists, where it is also demonstrated that contributions to a research joint venture may be asymmetric.

In what follows, we characterize the optimal provision of the non-pure public good. While equation (**??**) was useful for showing the intuition behind the asymmetric contribution result, whenever the focus is on interior solutions, it is more convenient to return to the original approach where the a_i's are treated as direct choice variables. Industry profit is then

$$\Pi = \sum_{i \in K} \pi_i = \frac{1}{[-P'(Z(a))]} \sum_{i \in K} [P(Z(a)) - \theta_i(a_i)]^2 \tag{22}$$

As shown in Appendix 2, differentiating (**??**) with respect to a_j gives the following first order condition for an interior solution for the variable a_j:

$$\frac{\partial \Pi}{\partial a_j} = \frac{Z(2s - EH)\left[P'(Z)B'(A) + \theta_j'\right]}{k + 1 - E_d} - 2q_j\theta_j' = 0 \tag{23}$$

where H is the Herfindahl index of concentration, defined as

$$H \equiv \sum_{i \in K} s_i^2 = \sum_{i \in K} \left[\frac{q_i}{Z}\right]^2$$

and it can be verified that

$$H \leq \left[\frac{Q}{Z}\right]^2 \equiv s^2$$

where $Q \equiv \sum_{i \in K} q_i$.Using (**??**) we obtain the (generalized) Samuelsonian rule of optimal provision of a non-pure public good

$$\frac{\left[\frac{\partial Z}{\partial a_i}\right]}{\left[\frac{\partial Z}{\partial a_j}\right]} = \frac{q_i\theta_i'}{q_j\theta_j'} \tag{24}$$

This, together with the equilibrium conditions of the Cournot game in the second stage of the game,

$$\widehat{q}_i = \frac{\widehat{P} - \theta_i}{[-P']} \tag{25}$$

determine the optimal vector $(a_1, ..., a_k)$.

To illustrate, consider for simplicity, the case of linear demand, with $P(Z) = \bar{P} - Z$, and just two domestic firms, with $\theta_i = \bar{c} - \delta_i(h_i - a_i)^\alpha$ where $h_1 = h_2 = h$, $0 < \alpha < 1$, and $\delta_1 > \delta_2 > 0$ Then (**??**) reduces to

$$\frac{2Q}{3}\left[\alpha\delta_i(h_i - a_i)^{\alpha-1} - B'(a_1 + a_2)\right] - 2\widehat{q}_i\alpha\delta_i(h_i - a_i)^{\alpha-1} = 0, \qquad i = 1, 2.$$

where $\widehat{q}_i = \widehat{P} - \bar{c} + \delta_i(h_i - a_i)^\alpha$ and $\widehat{P} = (1/3)[\bar{P} - B(A) - \theta_1 - \theta_2]$. It can be verified that $\widehat{q}_1 > \widehat{q}_2$ and $a_1 < a_2$.

The above example shows that at an interior solution, firms with greater absolute advantage in monotoring will be asked to contribute less resources to political activities. The intuition is as follows. For any given total amount of industry lobbying, A, the size of the quota is determined. Therefore the burden of A should be distributed among domestic firms in such a way that, given $B(A)$, the domestic industry's profit is maximized, given that the domestic firms are Cournot rivals in stage 2. But from (**??**), industry profit is increasing in the variance of cost reduction. Therefore, firms with absolute advantage in monitoring will be asked to contribute less a_i so that they become relatively bigger. This is due to the productive efficiency consideration.

We now ask the following question: does more heterogeneity among domestic firms lead to more protection? The answer turns out to depend on the curvature of the demand curve. Recall that Lemma 3.1 says that if the demand curve is convex ($E > 0$), then a given reduction in import quota tends to have an equalizing effect on firms's sizes (i.e., the big firms will expand by less than the smaller firms.) Therefore the marginal gain in domestic industry's profit, caused by an increase in A, is relatively low. This means that the industry will not spend much on lobbying. This effect will be mitigated, however, if firms are ex-ante sufficiently different. Thus we would expect that if E is positive, then A will be greater, the greater is the heterogeneity among firms. Now the Herfindahl index H is a measure of heterogeneity: given the number of firms, this index is smallest when firms are identical. Our reasoning indicates that, if E is positive, there would be a positive correlation between H and the size of the domestic industry's market share. The following calculation confirms our intuition. Summing (**??**) over all firms, we obtain

$$2s\{sE - k - 1\} + 2s(k + \beta) = (m + \beta)EH \tag{26}$$

where $\beta \equiv \sum_{i \in K} \beta_i$. Assume $E \neq 0$ then we obtain from (**??**):

$$s^2 + \frac{(\beta - 1)s}{E} - \frac{1}{2}(\beta + k)EH = 0$$

If $E > 0$, then the above quadratic equation in s has two roots of opposite signs[9]. Since s must be non-negative, we take the positive root

$$s = -\frac{1}{2}\left[\frac{\beta - 1}{E}\right] + \frac{1}{2}\sqrt{\left[\frac{\beta - 1}{E}\right]^2 + 2(k + \beta)EH} \tag{27}$$

This equation shows that, if $E > 0$ then the share of imports in domestic consumption, $B/Z = 1 - s$ is negatively correlated with the Herfindahl index of concentration of the domestic industry. This result should be interpreted with care because H and β are both endogenous.

Proposition 4.2: Assume $E > 0$. Then the share of imports in domestic consumption tend to be inversely related to the degree of concentration of the domestic industry.

5 Conclusion

We have shown that in an asymmetric oligopoly where domestic firms allocate entrepreneurial time between lobbying for protection and internal control (monitoring), the availability of lobbying opportunity may have differential effects on the profit of individual firms. In fact, under non-cooperative lobbying, the ranking of profits will be reversed when lobbying becomes possible, if the monitoring technology exhibits increasing returns, or if the demand curve is locally convex. Such reversal may be attributed to free riding in a non-cooperative equilibrium. In the cooperative lobbying case, by definition there is no free riding. In this case the optimal allocation of lobbying effort entirely reflects the motive of reducing aggregate production cost. Our model also lends only limited support to the conventional wisdom that industries with greater concentration tend to obtain more protection. In our model, it is assumed that firms lobby for quantitative import restrictions, such as an

[9]If $E < 0$, we either have two real roots of the same sign or two complex roots. In the first case, any root with $s > 1$ should be excluded. The second case would indicate that the assumption that all firms have an interior solution $h_i > a_i > 0$ is not valid.

aggregate quota. Similar results can also be obtained in a model where firms lobby for tariff protection, see Hillman et al. (2000).

In this paper, whether firms cooperate or not is taken as exogenous. But our results on profit reversal points strongly to the possibilily of developing a theory of endogenous coalition formation in the lobbying game. Such a theory would have a flavor similar to that of the theory of endogenous vertical integration[10].

APPENDIX

APPENDIX 1: Proof of (??)

Let $C = C_{-i} + c_i(m_i)$. Differentiating (**??**) with respect to m_i yields

$$\frac{\partial \pi_i}{\partial m_i} = \frac{[P - c_i]\,[(2 - s_i)E_d - 2k]}{[-P'](k + 1 - E_d)} c_i'(m_i) \tag{28}$$

This derivative is positive if $E < 2k/(2 - s_{id})$, ie, if the demand curve is not too convex.

APPENDIX 2: Proof of (??)

From (**??**),

$$\frac{\partial \Pi}{\partial a_j} = 2\sum_{i\in K}\left[\frac{P - c_i}{[-P']}\right] P'(Z)\frac{\partial Z}{\partial a_j} - \frac{2(P - c_j)\theta_j'}{[-P']} + \sum_{i\in K}\left[\frac{P - c_i}{[-P']}\right]^2 P''(Z)\frac{\partial Z}{\partial a_j}$$

The proof is completed by noting the facts that $\frac{P-c_i}{[-P']} = q_i$ and that

$$\frac{\partial Z}{\partial a_j} = \frac{P'B' + \theta_j'}{[-P'][E_d - k - 1]}$$

APPENDIX 3: the case where the total resources are not constrained.

We now show that the main results in the text remain essentially unchanged if the h_is are not fixed, but instead they can be obtained at a cost, provided that the marginal cost of obtaining h_i are rising. In this case, the expression (**??**) in the text must be interpreted as gross profit, and net profit is define as

$$\widetilde{\pi}_i = \pi_i - \Omega_i(h_i)$$

[10] See Gaudet and Long (1996) for a model of endogenous vertical integration.

where $\Omega_i(h_i)$ is the cost of obtaining h_i.

It is convenient to define

$$\theta_i(a_i; h_i) \equiv \bar{c} - r_i(h_i - a_i) \tag{29}$$

and, with a slight abuse of notation, we write

$$\theta_i'(a_i; h_i) = \frac{\partial \theta_i}{\partial a_i} = r_i'(m_i)$$

We interpret $\theta_i'(a_i; h_i)$ as the marginal cost of lobbying, because it measures the increase in production cost when resources are diverted away from monitoring. Let $a = (a_1, ..., a_k)$ and $h = (h_1, ..., h_k)$. Then, with a slight abuse of notation, $Z = Z(a, h)$. From (**??**), firm i's net profit in stage 2 is

$$\pi_i^{net} = \frac{[P(Z(a,h)) - \theta_i(a_i; h_i)]^2}{[-P'(Z(a,h))]} - \Omega_i(h_i) \tag{30}$$

To find firm i's optimal choice of a_i and h_i , given the a_j's and h_j $(j \neq i)$, we maximize (**??**) subject to the constraints $h_i - a_i \geq 0$ and $a_i \geq 0$. Write the Lagrangian

$$L = \pi_i^{net} + \zeta_i[h_i - a_i] + \mu_i a_i$$

The first order conditions are

$$\frac{\partial L}{\partial a_i} = \, ,_i r_i'(m_i) + \Lambda_i - \zeta_i + \mu_i = 0 \tag{31}$$

and

$$\frac{\partial L}{\partial h_i} = -,_i r_i'(m_i) - \Omega_i'(h_i) + \zeta_i = 0 \tag{32}$$

where

$$,_i \equiv \frac{\partial \pi_i^{net}}{\partial Z}\frac{\partial Z}{\partial C} + \frac{\partial \pi_i^{net}}{\partial c_i} = \frac{(P - c_i)[E_d(2 - s_{id}) - 2k]}{[-P'](k + 1 - E_d)} < 0 \tag{33}$$

and

$$\Lambda_i \equiv \frac{\partial \pi_i^{net}}{\partial Z}\frac{\partial Z}{\partial B}B' = \frac{(P - c_i)(2 - s_{id}E_d)P'B'}{[-P'](k + 1 - E_d)} > 0 \tag{34}$$

We will focus on the case of an interior maximum. Then (**??**) gives

$$\theta_i'(a_i; h_i) = \frac{[2 - s_{id}E_d]B'P'}{[2k - E_d(2 - s_{id})]} \tag{35}$$

(note that both $2 - s_{id}E_d$ and $2k - E_d(2 - s_{id})$ are positive, by (**??**) and (**??**).) The condition (**??**) has an intuitive interpretation: at an interior maximum, an increase in the amount of resources devoted to lobbying will increase production cost by θ_i', (this is the marginal cost of lobbying) and this must be balanced by the marginal gain from lobbying, which consists of an increase in price (modified for factors such as market share, and the effect of a price rise on revenue) brought about by a decrease in the import quota. If the maximum occurs at a corner, we must have, in the case of zero contribution to lobbying, $\theta_i'(0; h_i)$ exceeds the marginal gain (the right-hand side of (**??**)); or, in the case of zero monitoring, $a_i = h_i > 0$, $r_i'(0)$ is smaller than the marginal gain from lobbying.

An interior maximum also implies

$$-,\ {}_ir_i'(h_i - a_i) = \Omega_i'(h_i) \tag{36}$$

This condition says that the marginal increase in gross profit obtained from increased monitoring must be equated to the marginal cost of obtaining resources for monitoring.

The second order conditions for an interior maximum are

$$\frac{\partial^2 L}{(\partial a_i)^2} \leq 0, \frac{\partial^2 L}{(\partial h_i)^2} \leq 0, \frac{\partial^2 L}{(\partial a_i)^2}\frac{\partial^2 L}{(\partial h_i)^2} \geq \left[\frac{\partial^2 L}{\partial a \partial h_i}\right]$$

In the case of linear demand, with $P = a - bZ$, the first two of these conditions reduce to

$$kr_i''(h_i - a_i) - bB''(A) \leq 0 \tag{37}$$

and

$$\frac{2k^2(r_i')^2}{b(k+1)^2} + \frac{2k(P - c_i)r_i''}{b(k+1)} - \Omega_i''(h_i) \leq 0 \tag{38}$$

Condition (**??**) is satisfied if r_i'' is negative, or not too positive, and condition (**??**) is satisfied if $\Omega''(h_i)$ is a sufficiently great positive number, or if r_i'' is sufficiently negative.

The following lemma will be useful:

Lemma A.1: If two firms i and j both have interior solutions, then the following relationship must hold:

$$\frac{q_i[(q_i/Q)E_d - 2]}{q_j[(q_j/Q)E_d - 2]} = \frac{\Omega_i'(h_i)}{\Omega_j'(h_j)} \tag{39}$$

Proof: From (**??**) and (**??**) we obtain

$$\frac{\Lambda_i}{\Lambda_j} = \frac{\Omega_i'(h_i)}{\Omega_j'(h_j)}$$

Use this and (**??**) to obtain (**??**).

Remark: In the special case where Ω_i and Ω_j are linear and have the same slope (e.g. when firms face a perfect capital market), then (**??**) implies that $q_i = q_j$ if both firms have interior solution $0 < a_t < h_t$, $t = 1, 2$. Thus, in this special case, firms would achieve the same cost reduction, because the lobbying decision and the cost reduction decision become separable under perfect capital market conditions. We will focus on the case of imperfect capital market. The proofs of the following propositions are straightforward, and will be omitted.

Proposition 3.1 A: If the functions $\Omega_j(h_j)$ are strictly convex, then Proposition 3.1 in the text remains valid .

Remark: the proof is similar to that of Proposition 3.1, except that the h_i are now determined endogenously by the conditions

$$\frac{\Omega_i'(h_i)}{\Omega_j'(h_j)} = \frac{P - \bar{c} + \delta_i m_i^\alpha}{P - \bar{c} + \delta_j m_j^\alpha} \tag{40}$$

Note the importance of the strict convexity assumption on the $\Omega_j(.)$ functions. If these functions were linear and identical, then an interior solution is not possible, because it would imply both $m_j/m_i = (\delta_i/\delta_j)^{1/\alpha}$ and $m_j/m_i = (\delta_j/\delta_i)^{1/(1-\alpha)}$.

Proposition 3.2 A: If the functions $\Omega_j(h_j)$ are strictly convex, then Proposition 3.2 in the text remains valid . In addition, if $\Omega_j(.) = \Omega_i(.)$ for all i, j then it can be shown that $\delta_i > \delta_j$ implies $h_i^* > h_j^*$.

Proposition 3.3 A: If the functions $\Omega_j(h_j)$ are strictly convex, and $\Omega_j(.) = \Omega_i(.)$ for all $i, j.$, then Proposition 3.3 in the text remains valid, with the words "without changing the endowments h_i of each firm" replaced by "without changing the functions $\Omega_i(.)$ for all i ."

Proposition 3.4 A: If the functions $\Omega_j(h_j)$ are strictly convex, then Proposition 3.4 in the text remains valid, and we also have the following additional conditions to determine the equilibrium h_i^* :

$$q_i \left[\frac{q_i E_d}{Q} - 2 \right] \left[\frac{P' B'}{E_d - k - 1} \right] = \Omega_i'(h_i), \qquad i \in K.$$

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Figure 1

Multiple Equilibria

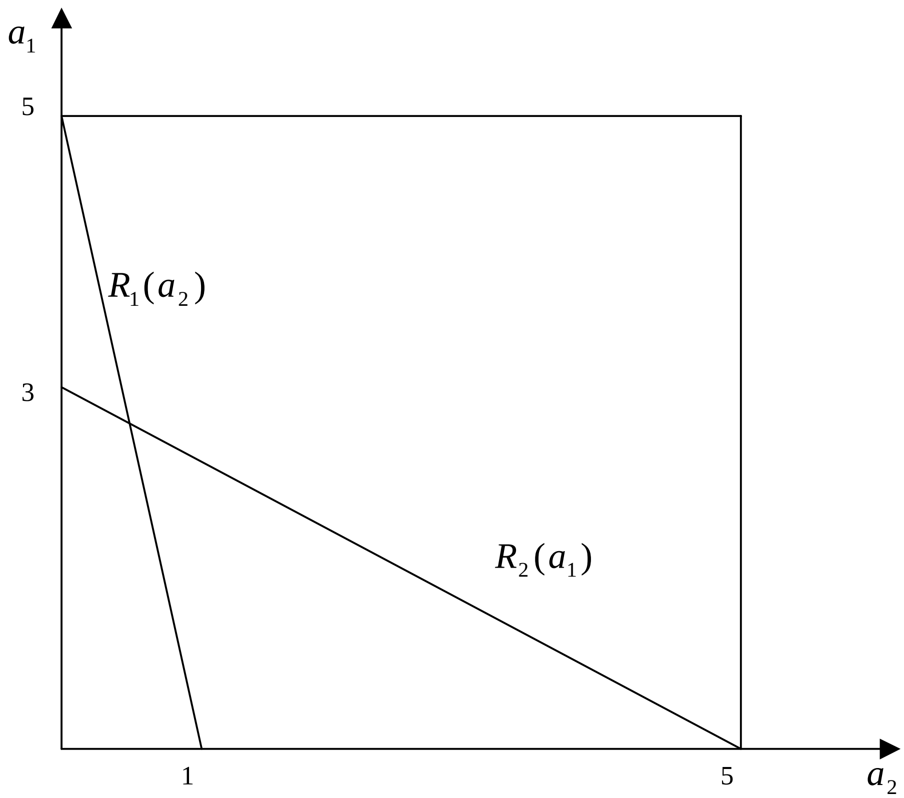


Figure 2

The Case: E = 0, $\delta_1 \geq \delta_2$, and Increasing Return to Monitoring

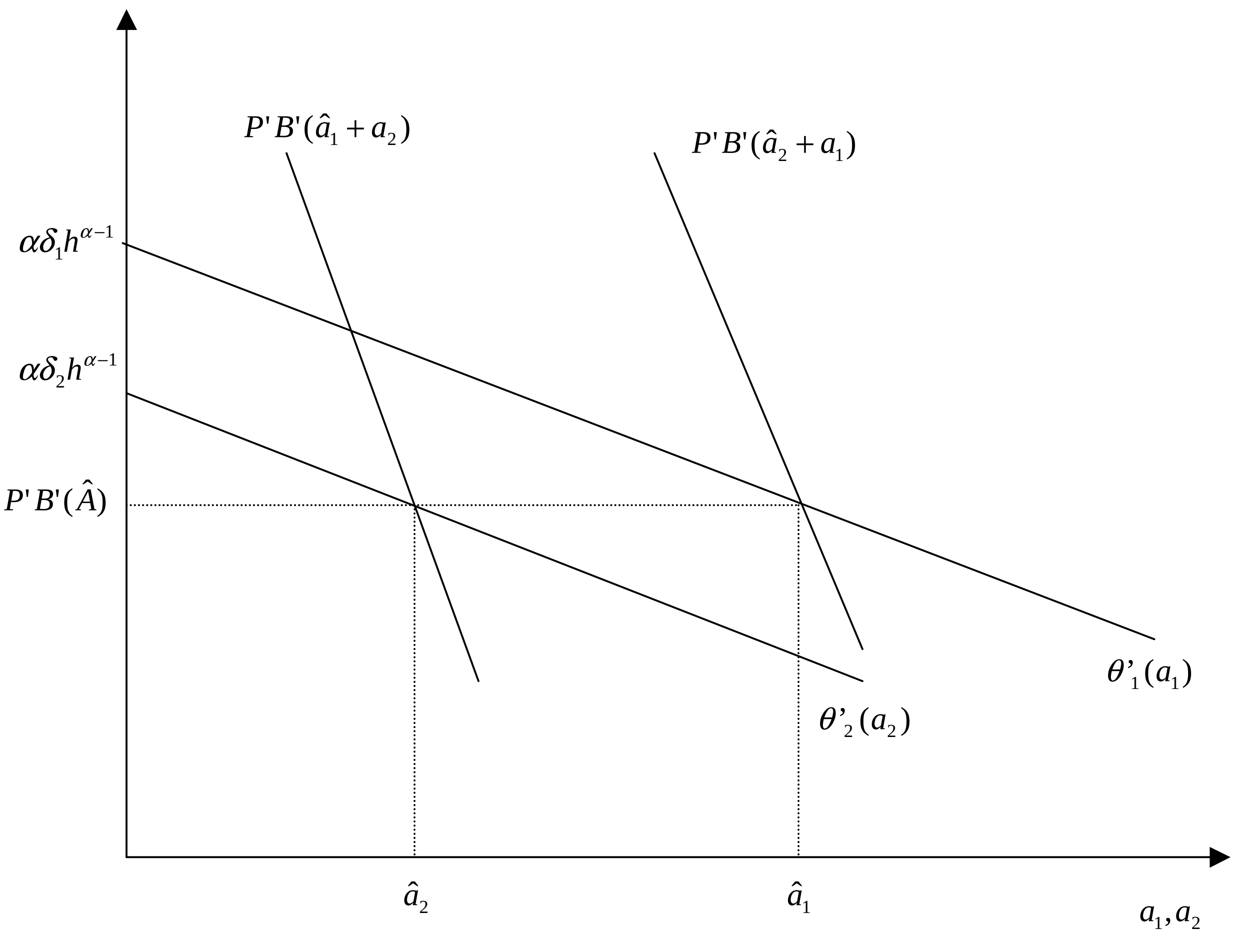


Figure 3

The Case: $E = 0$, $\delta_1 \geq \delta_2$, and Decreasing Return to Monitoring

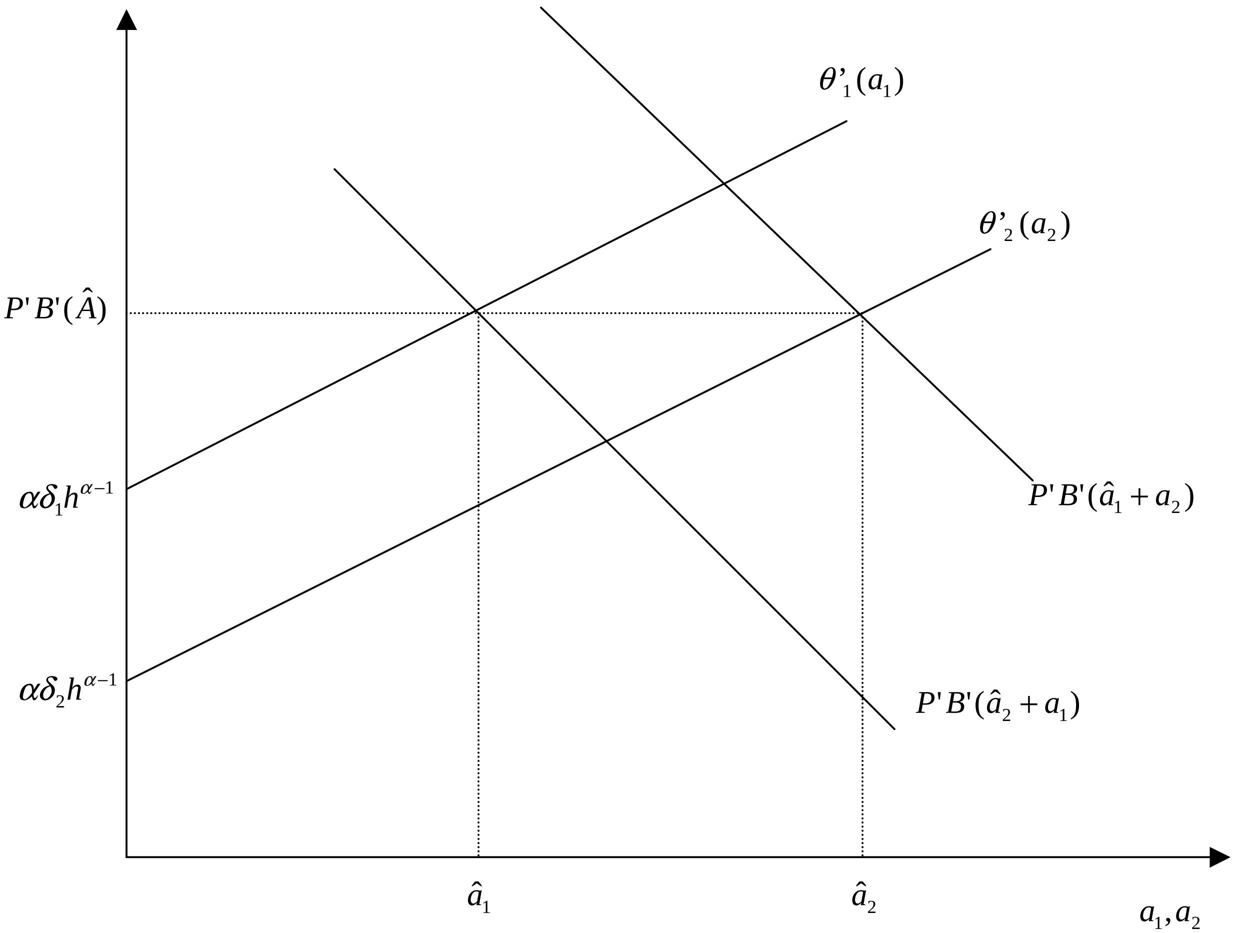


Figure 4

The Case: $E \leq 0$, $\theta'_1(\hat{a}_1) \geq \theta'_2(\hat{a}_2)$, $s_1 \geq s_2$

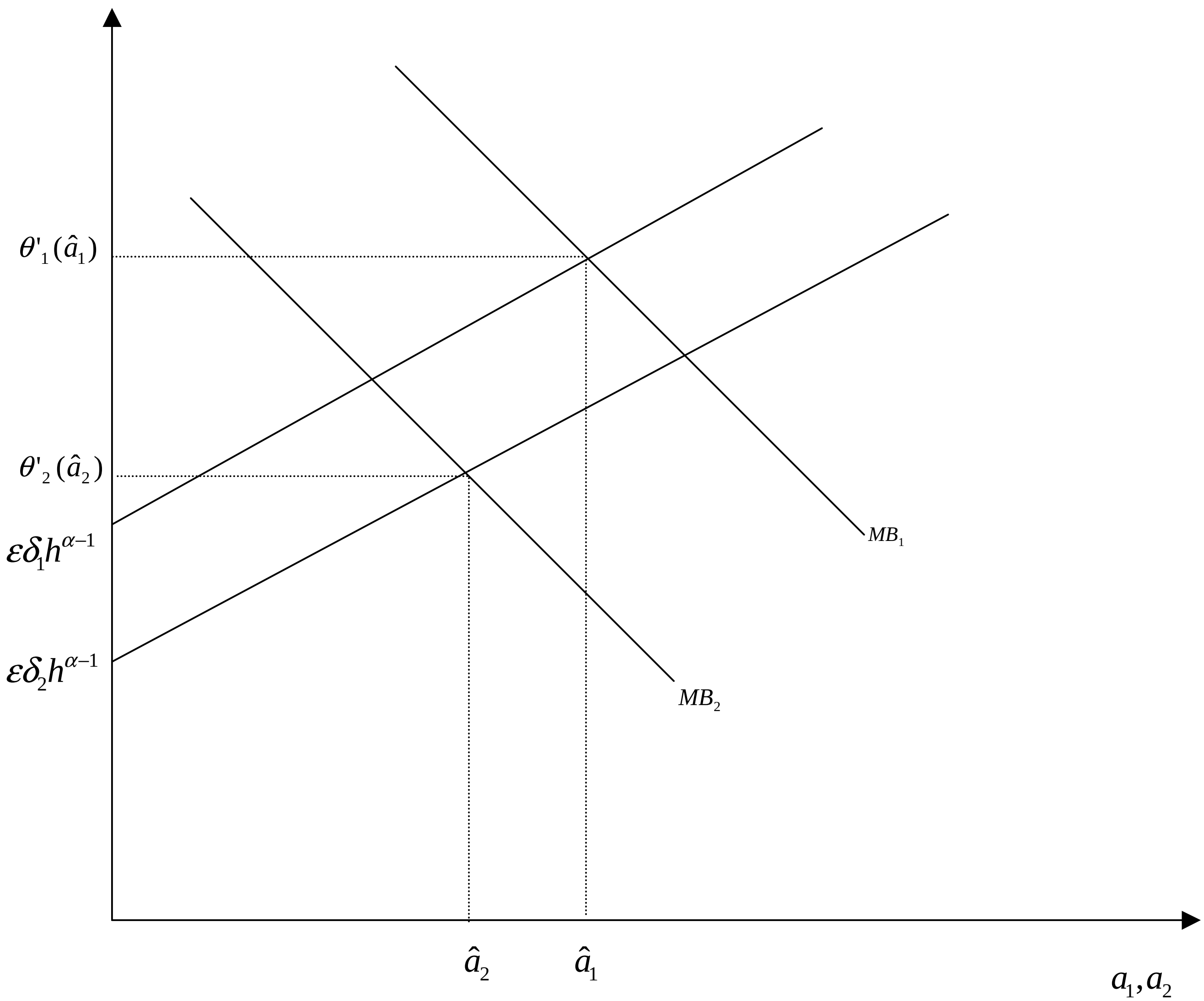
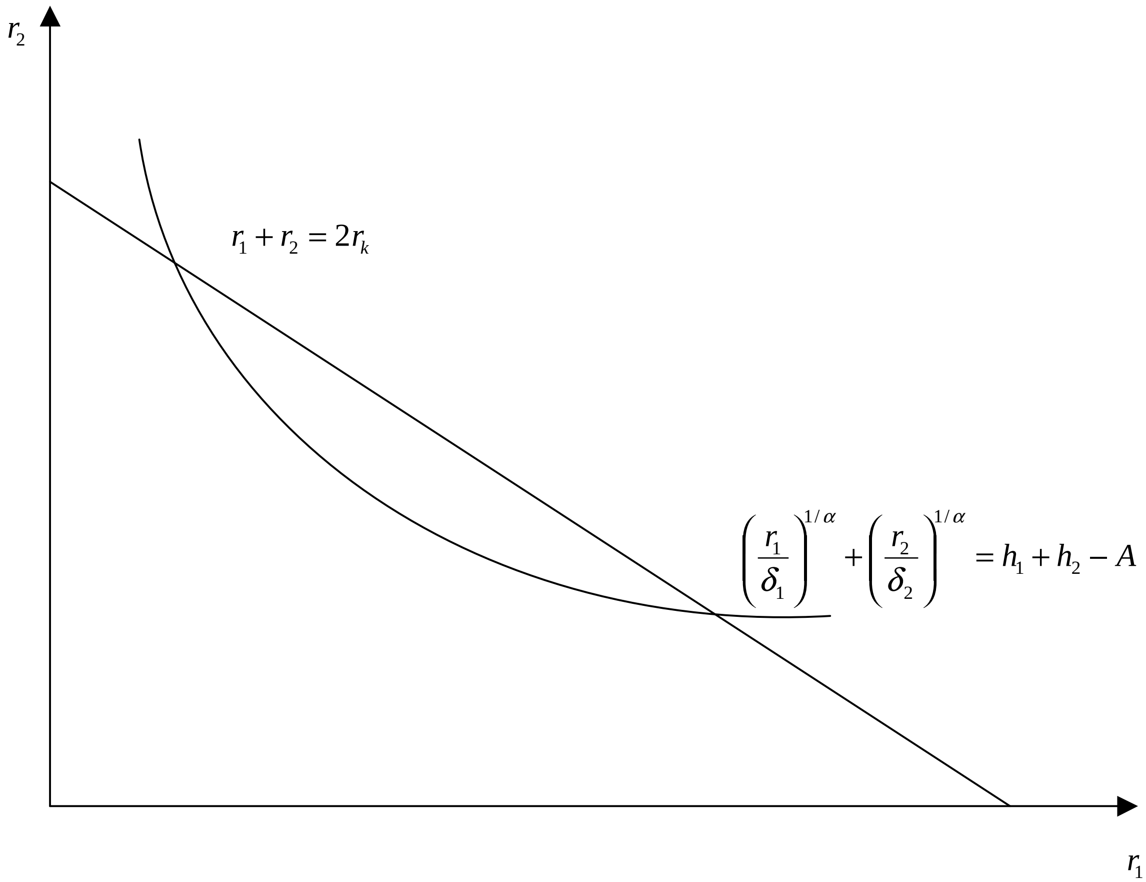


Figure 5

Asymmetric Cost Reductions



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